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Sacha Bourgeois-Gironde, Andrea Armeni

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## **The Apport of Modal Cognition to Information-Based Theories of Rationality**

### **Introduction**

Information-based theories of rationality offer a widely accepted system for evaluating the rationality of an agent's choice. All such models have to deal with seemingly irrational choices and with choices that do not reflect in actuality what the system predicts in theory. Hyperintensionality (where intensionality is not derived solely from an informational processing asymmetry, as, we will argue, in framing effects) and counterintuitive consequences of backward inductive reasoning present problems in choice and strategic reasoning that don't find easy or natural solutions within the information-based framework provided by such theories. Instances of intensionality – where the agent substitutes an internal sense for the reference in differentiating between options, to adopt a Fregean terminology – are typically handled by such theories by holding that when an agent is presented with two or several options that are normatively equivalent in the sense that they yield the same utility, the agent's systematic preference for one option among them exhibits a form of irrational behaviour, or at least a cognitive bias that should be explained in terms of a rationality failure on the agent's part. Such theories, that is, aim to solve the problems of intensionality and hyperintensionality by recourse to an information-based explanation – generally grounded in the concept of latent information: the agent regarded as salient and processed, *as information*, some information to which the experimenter or the theoretician was insensitive.

We wish to spell out how some abilities peculiarly linked to modal cognition (i.e. our grasping of modal features such as possibility or necessity) allow for a finer analysis of these phenomena than an information-based understanding allows. We leave for a future paper a comparable analysis of how modal cognition interfaces with reasoning in some strategic situations, such as the backward induction paradox occurring in situations like the farmer's dilemma or the centipede game. The particular scope of this paper, then, is to give a taste of how an agent's sense of possibility (and modality generally) leads him to

biases in choices that a purely information-based understanding will relate to some form of irrationality on his part. We argue that this conclusion by information-based theories is due to their not taking into account the modal aspects of the situation at hand. We rather see features of modal cognition as being a significant ingredient of our characterization as rational beings: the explanatory reduction to irrationality of the agent's choice loses some of the richness of that choice.

We replace the charge of irrationality by offering an enriched view of the decision that is grounded in the agent's modal abilities and spell out the fundamental cognitive features of such abilities of modal cognition in a way that captures the otherwise lost substance of the agent's choice.

From this application, one can easily extrapolate how the modal cognition-enriched approach offers a valid avenue for the solution of several problems within rational choice without having to attribute irrationality to the agent.

### **Information-based theories' shortcomings in explanations of intensionality**

One of the contexts in which modal cognition displays its explanatory strength is in the evaluation of the Bayesian approach to rational choice. We retain two basic aspects of Bayesianism here: the ability to grant priors to states of affairs and the ability to revise those priors in face of new relevant information. While the competence required of a subject by an information-based theory of rationality is in fact often combined quite explicitly with the ability to manipulate modal notions – namely, counterfactuals and comparative possibilities – the role played by this ability has been largely ignored within the context of such theories.

Information-based theories resort to latent information in the explanation of intensional effects in the following sense: the agent in his choice regarded as salient and processed, *as information*, some information to which the experimenter or the theoretician was unsensitive. That is, two or more options that were in principle normatively equivalent (and so regarded by the observer) are in fact not cognitively equivalent for the agent: he

discriminates among them, based on some subjectively sensitive information. This situation is most clearly evident in the context of framing effects.

Framing effects, understood as intensional failures, are characterized by the inappropriateness of the subject's intensional approach, or the substitution of two equivalent (or co-referential) terms in a common context. Decisions influenced by framing effects constitute a paradigm of such possible failures. Generally, an agent's "framed" response is seen as a failure in rationality.<sup>1</sup> We employ the concept of hyperintensionality to deal with situations where the intensionality expressed in the choices is not derived solely from an informational processing asymmetry. Modal cognition provides the tools for explaining framing effects without resorting to a charge of irrationality.<sup>2</sup>

Framing effects comes under many guises. One typical instance is the Asian disease experiment:

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs is as follows:

If program A is adopted, 200 people will be saved.

If program B is adopted, there is a 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.

A majority of subjects favour A over B.

Those same options can be redescribed in the following way:

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<sup>1</sup> "[Kahneman and Tversky] consider it a basic condition of the person being rational that his choices not be sensitive to the descriptions he accepts of situations, to how he understands the facts involved, to how these facts are 'framed' – they call this the principle of invariance. Others label it extensionality. The contrary of this is intensionality, and that is often said to mark a person as not being rational." Schick, F. *Making Choices, A Recasting of Decision Theory*, Cambridge, Cambridge University Press, 1997.

If program C is adopted, 400 people will die.

If program D is adopted, there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will be saved.

Given this second description, a majority of subjects favour D over C, despite the fact that A and C and B and D are equivalent. The distinction in preference based on their description, between options that are deemed equivalent by the observer is diagnosed as irrational.

C. McKenzie has led a series of experiments that tend to show that when choosing among differently framed normatively equivalent options, an agent has a particular reference-point in mind according to which he implicitly assesses the chosen option<sup>3</sup>. McKenzie's central hypothesis is that the agent compares the framed option he prefers with a pre-existing reference point (that is not spelled out in the set up) because it makes sense to him to make this comparison by resort to such a reference point: it would not be as relevant to make it with any other among the framed options. According to this interpretation, frames carry information beyond their literal content – including the information added by the agent in terms of a reference point. An agent is thus not only sensitive to a particular description of an option; he is also able to perceive how this particular description relates back in a relevant way to a certain reference point. McKenzie's illustration is clear: "The program to combat the Asian disease might more likely be framed in terms of lives lost if no one had ever died from the Asian disease before (and hence, zero deaths was the reference-point) than if the disease had routinely killed 600 people each year". This solution, as we shall see, does not eliminate intensionality out of choices entirely: the reference point itself might be framed. That is, the reference point itself may be described in such a way that its correlation with the framed option seems natural or obvious to the subject [*\*while in fact...*]. Originating framing effects is not exclusive of being one [*let's try to say this more simply*]. However,

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<sup>2</sup> In a related paper, "Backward Induction and Counterfactual Reasoning", we discuss the solution offered by the same approach to the problem of backward induction and the farmer's paradox.

under this interpretation of framing effects, intensionality seems to be locally eliminated and rationality reinstated. The agent does not choose arbitrarily a certain frame; he chooses it because it relates to some relevant reference-point.

Intensionality is locally eliminated if the reference points that subjectively trigger framing effects actually coincide with the (objectively triggered) reference points an observer might infer from observing a framing effect. For that to be the case framing effects must be related to objectively or publicly observable reference points; intensionality is to that extent eliminated. Bayesianism is furthermore restored in case, given a framing effect, an observer can predict the piece of background information that elicited the framing effect. The basic idea of McKenzie's approach is that the surplus of information provided by the description or frame is in principle publicly accessible by inferring reference points that most likely give rise to certain framing effects. McKenzie gives experimental results that tend to attest this coincidence.

The remaining shortcomings of this framework's approach to intensional cases flow from two of its presuppositions. The first presupposition is that there can be, at least from the point of view of the subject, fully extensional representations of the choice situation that present intensional features from a normative standpoint. This means that the representations are, from the subject's standpoint, informationally complete. The second and correlative presupposition is that information is all that it takes to rationally discriminate among options within the choice situation.

McKenzie's restoration of an information-based approach is, as we noted, local in the sense that some particular relation of comparison (in general in terms of higher or lower magnitude of some item) that the subject has in mind in choosing a certain frame is correctly inferred by an observer. In two respects, though, this local restoration of rationality is not the full-fledged reinstatement of an information-based framework. The first reason (related to the first presupposition) is that the comparison is in terms of

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<sup>3</sup> McKenzie, C., « What a speaker's choice of frame reveals: Reference points, frame selection, and framing effects » *Psychonomic Bulletin and Review*, 10, 596-602.

positive or negative valence: the subject chose one of the framed options because, according to the context at hand, it represented more or less of some given item (lives, money, etc). However, valence-framing effects are typically new to some basic emotions or attitudes (such as optimism or pessimism). The possible emotional component that attaches to the biased choice is not avoided by the making explicit of the reference point involved in the framing effect, even if it reveals some latent information. The second reason (related to the second presupposition) is that, if another framed option was chosen (say B in the case above) instead of the one actually chosen, it would still be possible for the observer, according to McKenzie's interpretation, to infer which reference point was latent for the subject. Now it is most likely that an agent who chose option A because of reference point  $R_a$ , would not be willing to admit that he would have chosen option B if he had reference point  $R_b$  in mind instead of  $R_a$ . The fact is that, first, he did not have  $R_b$  in mind, and, second, if he were able to make this full comparison of options with their reference points available, either he would be irrational in not seeing the equivalence between options, or he would see the equivalence and thus the available explanation of framing effects in terms of special reference points would lose its grip on the problem. It thus seems better not to postulate too much lucidity on the observer's part about how reference points subjectively trigger framing effects. This means that intensionality is not completely locally eliminated even under an information-based approach such as McKenzie's.

We offer a richer notion of decision-making that treats intensional cases without recourse to an explanation based on irrationality and that is not subject to the shortcomings of the purely information-based approach proposed by McKenzie. With respect to the first McKenzie presupposition, namely the possibility of extracting extensional representations of a choice situation even when it instantiates a framing effect, we apply the concept of hyperintensionality. In hyperintensional situations, intensionality cannot be merely attributed to an informational processing asymmetry.

The second McKenzie presupposition leads to a more fundamental revision of the framework. The presupposition's shortcoming in these respects is due, as we saw, to a

conception of cognition that is based exclusively on information. We propose to spell out features of a cognitive ability that deals specifically with possibilities, and term it modal cognition. The introduction of this richer notion of cognition provides a more satisfying solution by avoiding the two pitfalls discussed above.

While the information-based framework only deals with cases of intensionality caused by subjective information that is not shared, it may be the case that a choice was not due to some underlying subjective information but to an independent choice, or again to a preference not based on information processing. Framing effects may thus be due not to subjectively latent information but to some non-Bayesian preferences for a given description of an option.

### **The concept of modal cognition**

Viewing the agent's choice failures, as understood by information-based theories of rationality, in terms of their ability to handle concepts of possibility, or modal cognition, makes those failures better interpreted and avoids the limitations of a purely information focused approach and the charges of irrationality it mandates.

Modal cognition involves three separate abilities: the conceivability of something as possible, the ordering of those possibilities and the ability to reason counterfactually (as opposed to conditionally). We will analyze these abilities in turn and highlight how each plays a role in the solution of rational choice problems that pose challenges to the standard information-based theories.

#### **1. Conceiving the Possible**

An agent's sense of possibility reaches farther than the possibilities that are actual, but conceivability does not necessarily entail possibility. The consideration of sets of conceivable options as sets of possibilities can thus run an agent into trouble. An example of this sort of trouble is given by modal illusions. Intensional phenomena in choice



situations may be due to a subjectively mistaken assessment of some option in the choice set as being possible while in fact it is not. An agent is subject to a modal illusion when two possibilities that are irreconcilable (although they are both conceivable) seem epistemically equivalent. An example of modal illusion would be for a subject to experience no epistemic qualms in accepting the possibility that water is not H<sub>2</sub>O while the subject also accepts some normative standpoint that brings forth the a posteriori necessity that water is H<sub>2</sub>O.

Modal cognition provides the tools to explain the modal error that can occur in the form of two options in the set representing two possibilities for the subject while they are not in fact both possible, individually or jointly. An explanation of such phenomena in terms of modal errors need not resort to irrationality, much as an explanation of an arithmetic error in terms of mathematics need not do so.

## **2. Comparison and ordering of possibilities (choices)**

A separate ability governs the comparison between possibilities, the notion of modal distance (how far possible worlds are to the actual world), and the ordering of alternatives as more possible or less possible.

This rating of possibilities, even conjunctive or complex ones, does not require an inferential structure of their inner construction. An agent is thus able to compare between possibilities without endorsing the theoretically corresponding counterfactual statements. The orderings, that is, do not correspond at times to more deductive frames of the comparison, nor do they require counterfactual thinking. Because of this, the way one orders possibilities does not necessarily correspond to one's acceptance of corresponding counterfactual statements. It is thus necessary to deal in understanding an agent's evaluations of possibilities with the distinction between modal intuitions, as discussed under the first ability, and ability to perform counterfactual reasoning. This cognitive distinction is ignored by information-based theories, which generally acknowledge but one type of quasi-deductive modal ability: conditional reasoning. The distinction

provided by an analysis in terms of modal cognition thus offers a richer view of the ability to compare and order possibilities.

### **3. Counterfactual reasoning**

A third ability within modal cognition helps explain the way agents differentiate between conditionals and counterfactuals, where the latter are seen as more akin to a sense of modality, while the former are more deeply rooted in pure deductive reasoning. Conditionals focus on actuality and are linear and future-oriented. Counterfactuals imply a shift from actuality and generally a reference to an unactualized change in the past. Unlike conditionals, counterfactuals require a full modal semantic for their interpretation.

As already mentioned, the ability to reason counterfactually can be distinguished from the more basic ability to entertain modal intuitions. Counterfactual reasoning is, however, deeply rooted in that more basic ability.<sup>4</sup> This can provide a reading key for some experimental data showing that levels of epistemic revisability in face of new or contradictory information differ widely in counterfactual and in conditional contexts.

The general lesson of these three abilities is that significant biases or failures can occur when deductive abilities and features of modal cognition are combined.

### **The Contributions of Modal Cognition to Rational Choice**

In this section we will preview how each of the three abilities outlined above provides the foundations for a richer interpretation of seemingly irrational choices. The specific example of modal illusions and framing effects will be dealt with in the following section.

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<sup>4</sup> Indeed, all three abilities build one on the other: ability one is prior to ability two, which is more complex, and ability three requires the mental tools of abilities one and two. We speak thus of three levels of modal cognition as well as of three abilities. We note that at level three, counterfactuals are conflated with conditionals; at level two, ordering possibilities may diverge from classification of corresponding counterfactual statements; at level one, conceivable options may not yield actualizable choices.

**Apport of Ability 1 – Conceiving the Possible**

The understanding of the first ability of modal cognition offers simple solutions to the problems of modal illusions, that is, the problems caused by a sense of possibility that reaches farther than actual possibility. An agent may make seemingly inconsistent choices in allowing for one possibility while at the same time having agreed to the necessary nature of a state of affairs that is not reconcilable with that possibility. Instead of merely treating this instance as a case of agent irrationality, modal cognition's more refined understanding of conceivability of possibilities allows for the implementation, as later shown, of a two-dimensional modal semantics that solves the seeming inconsistency. The idea is to consider that the agent who seems to accept as possible one necessary (or impossible) statement and its negation does not regard as equivalent common terms as they appear in the different statements. There is a surface equivalence for the listener, but not a subjective equivalence for the subject, when the subject holds that necessarily water is  $H_2O$  and, at the same time, water is possibly not  $H_2O$ . The speaker has shifted the reference of his terms as if now they were merely homonymous from one context to the other. A 2-Dimensional Modal Semantics (2-DMS) framework clarifies the way in which the agent has shifted the reference of his terms. Of course a 2-DMS-style explanation has to be cognitively plausible. Without fully discussing this question here<sup>5</sup> we can rest on the remark that such a solution avoids attributing to the agent *prima facie* inconsistencies in his preferences and choices when two apparently irreconcilable options are equally accepted. The important point here, in analyzing the conflation of conceivable options and actualizable choices, is to think of how semantic shifts may underlie our acts of conceiving. It seems natural to use the words we have at our disposal as we master the reference of those words, in order to describe possible situations in which those words would lose or lack their usual reference. Without hinting at such blatant contradictions (such as the thought of a circular triangle), we can imagine that more subtle changes in the use of our words shape our intuitions of possibilities and may yield a heterogeneous (from the point of view of a normative semantic or modal

standpoint) domain of possibilities. The use of a disambiguating device such as 2-DMS keeps one safe from inconsistency while preserving heterogeneity. We shall present below how a 2-DMS approach can shed light on framing effects and spell out in some further details this framework.

### **Apport of Ability 2 – Ordering of Possibilities**

A well-admitted thesis in the literature on counterfactuals is Lewis's equivalence between counterfactual statements and comparative possibilities statements. Informally, according to Lewis<sup>6</sup>, a counterfactual of the form

If A were the case, then C would be the case

is theoretically equivalent to the conditional possibility statements

If A is possible, then the possibility that A and C is closer to actuality than the possibility that A and non-C.

This equivalence, however, might be less than fully supported by cognitive data. Modal intuitions, in terms of what we are prone to agree with, are less constrained than counterfactual pieces of reasoning. We might refuse to accept as valid the counterfactual

If Jupiter were closer to the Earth, the tides would have larger amplitudes

and yet rate the unordered possibility set

{stronger tides, Jupiter closer}

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<sup>5</sup> The reader is directed to the authors' "Backward Induction and Counterfactuals – a cognitive approach" [to appear].

<sup>6</sup> Lewis, D. "Counterfactuals and Comparative Possibilities", *Journal of Philosophical Logic*, 2, 1973, pp. 418-46.

as more likely than

{no stronger tides, Jupiter closer}.

An information-based approach ignores this distinction between levels of constraint. Therefore, something that amounts to a violation of a constraint in that approach, and is thus deemed irrational, appears not to have been subject to the constraint in the first place in a modal cognition approach. A modal cognition approach, on the other hand, provides the tools for interpreting the reasoning behind this sort of distinction.

### **Apport of Ability 3 – Differentiating between conditionals and counterfactuals**

The distinction between counterfactuals and conditionals is fundamental for any theory of rationality. Information-based theories of rationality rely to a great extent on the ability to revise prior beliefs. In the analysis thereof, however, such theories do not distinguish between revisions in the conditional and in the counterfactual context. As documented by Byrne<sup>7</sup>, belief revisability occurs to a lesser extent in counterfactual contexts than in conditional ones. Byrne has experimentally shown, for example, that reasoners revise their beliefs in a factual conditional more than in a counterfactual conditional. In factual conditional contexts data show that reasoners facing contradictions do not tend to reject their premisses but seek to accommodate them in ways that solve the contradiction. In the case of counterfactuals there is a lesser tendency to “save” the reasoning from inconsistency and to adapt premisses and information in view of epistemic coherence. Contradictions are more at home in counterfactual settings. This is understandable if one sees that most reasons that lead an agent to revise in conditional settings do not have to hold when the same grounds for revision, such as the presence of new information contradicting some previously accepted premise, occur in a counterfactual line of reasoning. The different degree of revision may be due to the fact that the different modal intuitions that underlie counterfactual reasonings (like the intuitions that Jupiter could be

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<sup>7</sup> Byrne, R.M.J. & Walsh, C.R. (2002). « Contradictions and counterfactuals: Generating belief revisions in conditional inference » In Proceedings of the 24th Annual Conference of the Cognitive Science Society. Mahwah, NJ: Lawrence Erlbaum Associates.

closer to the Earth and the intuitions that the tides could be stronger, normally corresponding to the counterfactual statement that if Jupiter were closer to the Earth, tides would be stronger) do not necessarily mentally combine in truth-functional complexes but can remain unrelated, from a deductive or a compositional perspective, modal chunks. One can hypothesize that mental models underlying respectively conditional and counterfactual reasonings might differ as to their internal truth-functional consistency.

S. Bourgeois Gironde and al.<sup>8</sup> have more generally documented the fact that modal contexts imply lesser cognitive sensitivity to information and corresponding epistemic updatings than non-modal contexts. The perception of a modal operator tends to attenuate the effort to revise, even with respect to information that the subject would wish to update and keep coherent in absence of the modal operator. S. Bourgeois Gironde and al., for example, have measured reading times for short expository texts involving contradictions between their conclusion and one of the premisses. The study showed that, when the contradiction was embedded in a modal statement, the reading time of the contradictory statement is shorter than when it does not appear in a modal statement, tending to show that the subject is less sensitive to the presence of a contradiction in the scope of a modal operator and does not proceed to bridging inferences in order to see where overall consistency failed.

This lends support to the notion that the ability to reason conditionally and that of reasoning counterfactually should be accounted for separately.<sup>9</sup>

Not only does the agent tend to revise less his prior beliefs when they are embedded into counterfactual contexts, but also the comparison of possibilities and the attribution of distinct priors to possible alternate courses of action in a game-theoretic game does not

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<sup>8</sup> Bourgeois Gironde, S., Palma, A., van der Henst, J.-B., Armeni, A., “Initial Review of the Results from the Modal Acceptance Experiment”, this website.

<sup>9</sup> Relevantly, the two abilities are often conflated in applied thinking about counterfactuals, e.g. in the legal context. The experimental results, as well as the three-level set up of the abilities, suggest that a more refined approach to counterfactual thinking is necessary for more careful applications.

systematically correspond, from a cognitive standpoint, to the associated counterfactual structure of the game. These basic features of modal cognition and the sui generis biases they create in reasoning tasks should be kept in mind when assessing the rationality of cognitive endeavours, such as the consideration of a set of options and the choice among them, which typically call for informational and modal competence.

### **Modal Cognition's Approach to Intensional Failures: The Problem of Hyperintensionality**

Not only complex strategic reasonings, but also basic choice situations, can exhibit intensional features, as the study of framing effects has widely shown. As discussed above, framing effects occur when two or more options which are logically or normatively equivalent lead to non-equivalent preferences or behaviours. This can be labelled an intensional phenomenon in the same sense as some words or sentences that share reference may not lead to the same epistemic or cognitive acceptance. In those cases, the key to understanding and discriminating between sentences, to adopt a Fregean terminology, is the sense – or the subjective cognitive impact – rather than the objective reference. Equivalently, one way to disambiguate between options that are normatively, but not subjectively, equivalent is to provide something like sense and context for those options. Subjective sense, in place of objective reference, is provided when, in particular, one interprets framing effects as conveying some particular perspective taken by the agent over the situation.

We saw how a typical informational approach explains framing effects by resorting to a reference point. This is problematic because the subject's particular reference point could itself have been influenced by framing in the first place. This possibility would only be avoided by providing a justification for the choice of such a reference point. To do so, however, one must call back a series of reference points, which gives rise to an open regress. Intensionality, or specifically the framing effect, cannot be eliminated simply by indefinitely increasing the arity of a relation that seeks to make explicit latent

information. The informational framework, moreover, only deals with cases of intensionality caused by subjective information that is not shared. It may be the case that the choice of a particular option was not due to some underlying subjective information but, more fundamentally, to an independent choice, or again to a preference not based on information processing.

Framing effects may thus be due not to subjectively latent information but to some non-Bayesian preferences for a given description of an option; for this reason, information-based theories do not fully explain framing effects.

Framing effects based on the variation of some attribute of an option can illustrate this strategy. The alternate descriptions of the given medical treatment discussed above as resulting either in 75% survivors or in 25% mortality, while logically equivalent, may yield a preference for the 75%-described outcome if, by favouring this specific survivors-frame, the agent implicitly relates it to a lower previous success rate of a similar treatment. The agent is, in this context, showing his sensitivity to the increasing rate of success in relation to a reference point he keeps in mind. The option chosen is located in a broader description of the situation encompassing different subjective perspectives.

The conclusion of the information-based approach that the agent is acting irrationally can be avoided if the observer accepts that the choice situation may present some irreducibly intensional features – that is, the agent regards as irreducibly distinct options that are normatively equivalent. Where the situation is inherently intensional, it is incorrect to deem irrational the agent's intensional failure to realize the logical equivalence of the several options. What does it mean then for a situation to be “inherently intensional” and for the agent to be still acting rationally? It is merely the fact that the choices can be understood as several possibilities to be or not to be realized. The fact that under framing effects possible options are logically equivalent should not lead to different possibilities being anticipated by the subjects as normatively equivalent. If the subject is actually ‘victim’ of a framing effect, his error in considering the two choices as non-equivalent should be interpreted as an error in modal reasoning. A modal error is not necessarily an



instance of irrationality because the error may be predicated on a conception of possibility by the agent that is hyperintensional and quite simply not shared. The error is modal in nature because it is based on a failure in perceiving the equivalence. The reason why the agent's attitude cannot be deemed necessarily irrational is that there is no necessary conclusion to irrationality of the agent if the agent is acting according to a private sense of possibility. The fact that the two options are normatively equivalent from the informational standpoint does not mandate that the two options be similarly equivalent in the agent's evaluation of possibilities. The diagnosis of modal error thus avoids the conclusion that the agent is acting irrationally, which appears unjustified once the hyperintensional nature of the choice is spelled out.<sup>10</sup>

The substantive question about rationality and framing effects, in particular, is then bypassed thanks the analysis of the contribution a certain cognitive ability makes to decision processes. To spell out our diagnosis we will continue to tackle the problem of framing effects and will characterize it as a type of modal error. [\*\* I don't think this paragraph is necessary – I am not clear about the first sentence]

### **Framing effects and modal illusions: The Two-Dimensional Modal Semantics Explanation**

One way of explaining framing effects, without the reduction to the latent information framework, is, to borrow from the philosophical literature<sup>11</sup> and say that the subject is victim of a 'modal illusion'. Let's spell out that suggestion and see how the agent's rationality can be preserved when choice situations are analyzed from a modal angle. To see technically the contribution of modal cognition to the solution of intensional and hyperintensional situations, let us start by looking at the isomorphism between framing effects and modal illusions.

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<sup>10</sup> The meta-epistemic question is whether this procedure of disambiguation has to be systematically accepted by the subject when he is a victim of a modal error.

<sup>11</sup> See the anthology by Gendler, T. S. and Hawthorne, J., "Conceivability and Possibility", Clarendon Press, Oxford 2002, especially the introduction where the philosophical notion of modal illusion is presented.

Framing effects share this common structure:

$A \text{ indiff } B$

(two options are normatively equivalent)

and still

$A > B$

(A is behaviorally preferred to B).

Modal illusions exhibit the reverse isomorphic structure:

$A \approx B$

(A seems epistemically equivalent to B)

while in fact (from an accepted normative standpoint underlying modal judgements)

$A >^* B$

(A is a closer possibility than B)

Let us return to the previous example of a modal illusion where a subject experiences no epistemic qualms in accepting the possibility that water is not H<sub>2</sub>O while the subject also accepts some normative standpoint that would bring forth the a posteriori necessity that water is H<sub>2</sub>O.

A first point to notice is the possibility that, given this isomorphism, the two situations of modal illusion and framing effects can be dealt with through a common framework; we believe that modal cognition offers that common framework.

Viewed in the context of modal cognition, a victim of framing effects can be said to have made a modal error, the diagnosis for which is found in 2-DSM. 2-DSM allows for a modalized sentence to be interpreted relatively to pairs of worlds rather than to worlds simpliciter. Any sentence, then, can be interpreted relatively to the actual world and relatively to any other world taken as actual; its modal or counterfactual content is then contrasted with either of the worlds considered as actual, whether actually actual or not. So in jointly admitting the stance that “Water could be different from H<sub>2</sub>O” and that “Necessarily water is H<sub>2</sub>O” the 2-DMS reading of the apparent inconsistency holds that in the first case the subject envisions as its reference point in one case the counter-actual world, and in the second case the actual world.

2-DSM disambiguates reference-worlds for the interpretation of modal sentences but those reference-worlds are not exactly like the reference-points which were spelled out in order to make the choice of framed options informationally correct even though they share something with them: privacy. Their common ground is that a counter-actual world is associated with some private sense that the subject lends to a sentence. Even if this private sense can be found in more than one and even in a majority of subjects, counter-actual worlds reflect subjective meanings people associate with the accepting of some sentence as possible while it is normatively impossible. People are facing an impossibility and they find private meanings that describe a possible scenario they circumstantially take as their reference-world. Now, intensionality would be limited, in the case of modal illusions, if the worlds people select as their points of evaluation could be systematically related to the actual world as we know it. This, however, can't be the case. In order for 2-DSM to properly apply, no backward reference to actuality (actual actuality) can be made in the context of a counter-actual standpoint, lest the latter immediately cease to be a full-fledged counter-actual standpoint. A resort to a 2-DSM explanation of modal illusions does not per se allow one to have it both ways: private and yet explicitly informational.

This explanation is not based on an information-based framework and as such it does not resort to a charge of irrationality. Irrationality is avoided for the simple reason that 2-

DMS is a disambiguating framework. It disambiguates the kind of modal context an agent has in mind when faced with several possibilities. If it were not a disambiguating framework there would be incoherence. But by providing a modal context for the agent's intuitions, the two intuitions appear as no longer related, and as such they can be jointly entertained without a conclusion of inconsistency.

In both the framing effect and the modal illusion context, subjects make themselves blind to some informational equivalence between two options and favour one option/possibility over the other. Favours one possibility can be interpreted as taking this possibility as implying a correlated reference world different from the one the other possibility would imply and failing to see that the two possibilities in principle refer back to the same world. We have here a kind of in-built modal illusion in the following sense. It is as if, indeed, the two options in a framing effect were not counterfactually related one to another by the subject, in which case their equivalence is not immediately perceived and can remain unperceived if there is no cognitive procedure which puts back together the separate modal intuitions. The subject does as if the two options reflected two essentially different things rather than two distinct descriptions of the same thing. In other terms the modal illusion is here deepened into a form of objectual illusion. The various options presented in a choice situation in which a framing effect arises are perceived as different objects even more than as different descriptions of the same object. This deepened illusion is not one in which an informational diagnosis has grip on. However it seems a plausible interpretation of what kind of errors are involved in framing effects.

One can express the reverse isomorphism between modal illusions and framing effects in more than one way. In a modal illusion we need a disambiguating framework in order to realise that we use the same words to refer to different objects. In a framing effect we seem to disambiguate when we need not because the terms (the descriptions associated with the options) actually refer to the same object (option). When an agent rejects the 2-DMS diagnosis for modal illusions because one maintains that he uses the terms to refer back to the same thing (for instance to water as we know it), one makes what could be

called a hyperrigid use of those terms: he wishes to maintain reference of those terms in context where such reference is not available. When victims of framing effects, on the contrary, agents do not see that descriptions bear on the same object, that is, they fail to see coreferentiality and show an extreme form of intensionality (in not allowing for the substitution of equivalent descriptions).

This isomorphism between modal illusions and framing effects may be the symptom that those two types of cognitive biases may represent two faces of a common phenomenon: the role modal cognition plays in decisions as well as conceivability. This cognitive ability has some particular features and when conflated with other cognitive abilities such as reasoning or processing information, some apparent mistakes or failures may appear. One needs not diagnose deep irrationality though, to the extent that we are able to identify the biases and to disambiguate modal reference points (rather than informational reference points), we rather see the typical contribution that modal cognition make to decision processes, a contribution that was shadowed by purely informational approach to decision processes and biases attached to them.

### **Framing effects and modal cognition, recap**

Some features of modal cognition contribute to the occurrence of framing effects, namely the fact that an agent sees distinct possibilities rather than seeing different descriptions of different informational pieces characterizing the same option and is not considered as irrational. What we are faced with is in fact a modal error, which can be diagnosed, and not merely an instance of irrationality.

The modal cognition approach also captures the sense that dealing with counterfactuals is an intuitive process, not merely an informational framework. The intuitive process can be captured by an understanding of modal cognition, but there is no way that a purely information-based approach can get to the intuition about counterfactual reasoning.

If there are such correlations between framing effects and implicit reference-points, when faced with framing effects, one can justifiably infer that some information, under the guise of a reference-point, is latently processed by the subject [see McKenzie].

## Conclusion

A fuller understanding of the abilities of modal cognition offers a richer interpretive key for phenomena such as intensionality and hyperintensionality and offers significant contributions to an understanding of such seeming irrational choices as those evidenced by framing effects that does not require a charge of irrationality. This is but one application of modal cognition – other contexts, such as a revision of the backward induction paradox, further will show that modal cognition's contributions are quite rich. The modal cognition approach to intensional phenomena in choice-situations fits well enough within an information-based framework centered on the notion of information: it retains the assumptions that perspectives taken on situations can be spelled out in terms of relations between implicit reference-points and one of the framed options and that all there is to a subjective perspective in a choice-situation is some implicit information that can be made explicit.

Such a richer sense of cognition is needed in choice and strategic reasoning, lest a subject's natural interpretations of modal situations be unnecessarily reduced to irrationality, with the subsequent loss of the full richness of the choice.

At the same time, such an understanding of the underlying cognitive abilities may also weaken information-based theories, if this richer cognitive view shows that the decisional process can only partly be explained in terms of a processing of information.